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File Code: 2880 Geology and Karst Resources  
Route To:

Date: October 31, 2015

**Subject:** Final Geology, Minerals, Karst and Cave Resource Report for the Kosciusko  
Vegetation Management Watershed Improvement Project

**To:** Delilah Brigham, Planning Program Specialist/IDT Leader  
Molly Simonson, Writer Editor

You have asked me to report on the Geology, Minerals, Karst and Cave Resources within the Kosciusko Vegetation Management Watershed Improvement Project and the proposed actions. Additional resources thought to be karst and cave resources by non-karst educated personnel were also taken into account, and where applicable, are discussed. This report reviews again the geology and karst resource development of the Kosciusko Island Project Area, and outlines previous work conducted in the area for cave and karst resource assessment. Finally, the proposed young growth units are addressed as to the cave and karst resources located within each and prescriptions are

### **Geology and Glacial History**

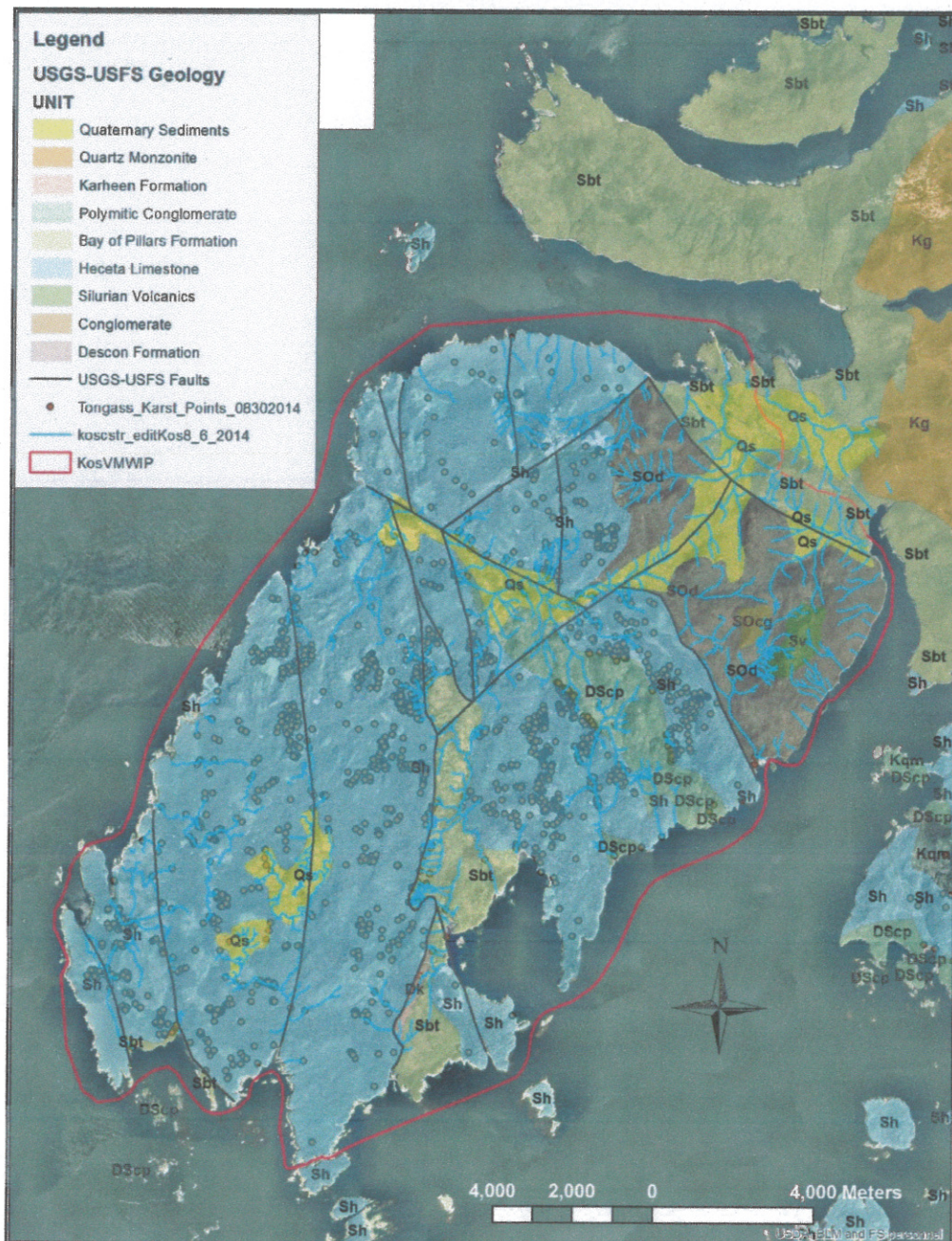
The project area is primarily underlain by the Upper Silurian aged Heceta Limestone. This formation is characterized by light gray, massive, limestone, with abundant amphiporoid corals, dasycladacean algae, oncoids, and brachiopods. Limestone also contains subordinate stromatoporoids, gastropods, pelecypods, bryozoans, trilobites, graptolites, conodonts, and aphrosalpingid sponges. Aphrosalpingid sponges form cores of stromatolitic mats. Unit contains thick lenses of polymictic conglomerate, limestone breccia, and sandstone.

The eastern portion of the project area contains a band of Lower Silurian aged polymictic conglomerate. The polymictic conglomerate in a green volcanic wacke matrix. Conglomerate is mostly matrix supported, and contains rounded and angular clasts of volcanic rock, chert, limestone, and intermediate intrusive rock, and pink syenite. Forms massive layers that contain blocks and irregular masses of Silurian limestone. The conglomerate underlies and is laterally gradational to the Heceta Limestone.

In the eastern most and central portions of the project area in the Charlie and Bear Creek valleys and along the shoreline of Halibut Harbor the Silurian aged Bay of Pillars Formation is exposed. The Bay of Pillars Formation consists of grayish brown to gray fresh, tan to gray weathering graywacke, mudstone and calcareous mudstone. The dominant rock type is calcareous graywacke turbidites with carbonate clasts, fossil fragments, subordinate feldspar, quartz, and volcanic rock fragments, and patchy recrystallized carbonate matrix. Unit includes gray graywacke, tan calcareous wacke and dark gray argillite; massive conglomeritic debris flows, massive amalgamated sandstone beds, and turbidites consisting of graded beds with full Bouma sequences, and ungraded rhythmic beds with sharp contacts; isolated beds of thin-bedded, light gray, medium-grained limestone intercalated with argillite and graywacke. Graywacke beds



Along the eastern most portion of the project area is underlain by Silurian volcanics (Sv) and the Descon Formation (SOD). The Silurian volcanics consist of massive, dark green volcanic breccia, agglomerate, flows, and massive volcanoclastic and polymictic conglomerate. Compositions of volcanic rock range from intermediate to mafic, hypocrystalline to augite and feldspar porphyritic, with a felted plagioclase-epidote-chlorite groundmass. Conglomerate is gradational to breccia and includes both matrix-supported and clast-supported deposits. Volcanic rocks are locally interlayered with Heceta Limestone. Depositionally overlies the Bay of Pillars Formation. The Descon Formation is Lower Silurian to Lower Ordovician in age. It includes volcanoclastic graywacke turbidites, quartzofeldspathic wacke, conglomerate, sedimentary breccia, siliceous shale, black chert, and subordinate basalt flows and pyroclastic rock (Eberlein and Churkin, 1970, USGS USFS Mapping).



### **Fig. 1 – The Geology of the Kosciusko Island Project Area**

The rocks which underlie the project area are locally, intensely folded. Where less folded, they tend to strike north-south and northeast-southwest shallowly dipping to the west or northwest. Several north-south faults bisect the project area as strike-slip or as thrust faults. In places these faults have been offset by the structure which forms the Trout Creek valley. The geology of the area has been modified by mapping during the reconnaissance phase of the project and by a joint USGS/USFS mapping project on the island in June of 2006. These changes have been incorporated into the current GIS geology layer for the project.

The topography of Kosciusko Island and the project area have partially been shaped by the forces of continental glaciation and the alpine glaciers that coalesced with the continental ice flow during the Wisconsin Ice Age. Evidence suggests that the western most portion of the project area near Cape Pole may have been near the terminus of the glacial lobe which filled Sea Otter Sound. Stratified outwash deposits have been found in several places on the western portion of the project. Mount Francis and the slopes surrounding it likely were not glaciated during the Last Glacial Maximum. It is possible that the Island was deglaciated as early as 14,000 years ago. Shells bearing uplifted marine sediments have been noted from several sites within the project area. The extent of the shell-bearing raised marine sediments in the project area have not been fully mapped and nor have been dated. The glacially induced crustal displacements surrounding southern southeast Alaska are complex. Prince of Wales and the surrounding islands may have experienced a complex array of eustatic and glacio-isostatic crustal adjustments similar to those reported on the Queen Charlotte Islands (QCI) of British Columbia to the south. On Prince of Wales and the surrounding islands the oldest shell-bearing glacial marine sediments have been dated to between 9,200 and 9,700 B.P. The highest measured shell-bearing glacial marine sediments are found at approximately 12.5 meters a.s.l. Similar shell deposits have been located in the project area. The older shell-bearing glacial marine strata is not exposed above the present shoreline suggesting that, as has been reported in the Queen Charlotte Islands, an area of glacial forebulge developed persisting until approximately 9,700 B.P. Between 9,700 and 7,000 B.P. a marine transgression occurred submerging the land to a present depth of 12.5 meters as a result of the collapse of the forebulge. Sea levels fell between 7,000 and 5,000 B.P. to near their current relative position as a result of tectonic uplift and possible isostatic adjustment (Carlson and Baichtal, 2015). Evidence of this tectonic uplift can be seen within the project area along the shores of Halibut Harbor and the western most shores of Kosciusko Island. Raised terraces, shell bearing strata, sea caves and wave scoured overhangs and rock shelters hint at past sea levels and the uplift history of the area.

### **Minerals and Mining Claims**

The U. S. Bureau of Mines, during field investigations from 1990 to 1994, did not find any mines, prospects, or mineral occurrences within the North Prince of Wales Road project area (Maas et al. 1995). Bureau of Land Management mining claim activity reports indicate that there are no mining claims currently within the project area.

### Karst and Cave Resources within the Project Area

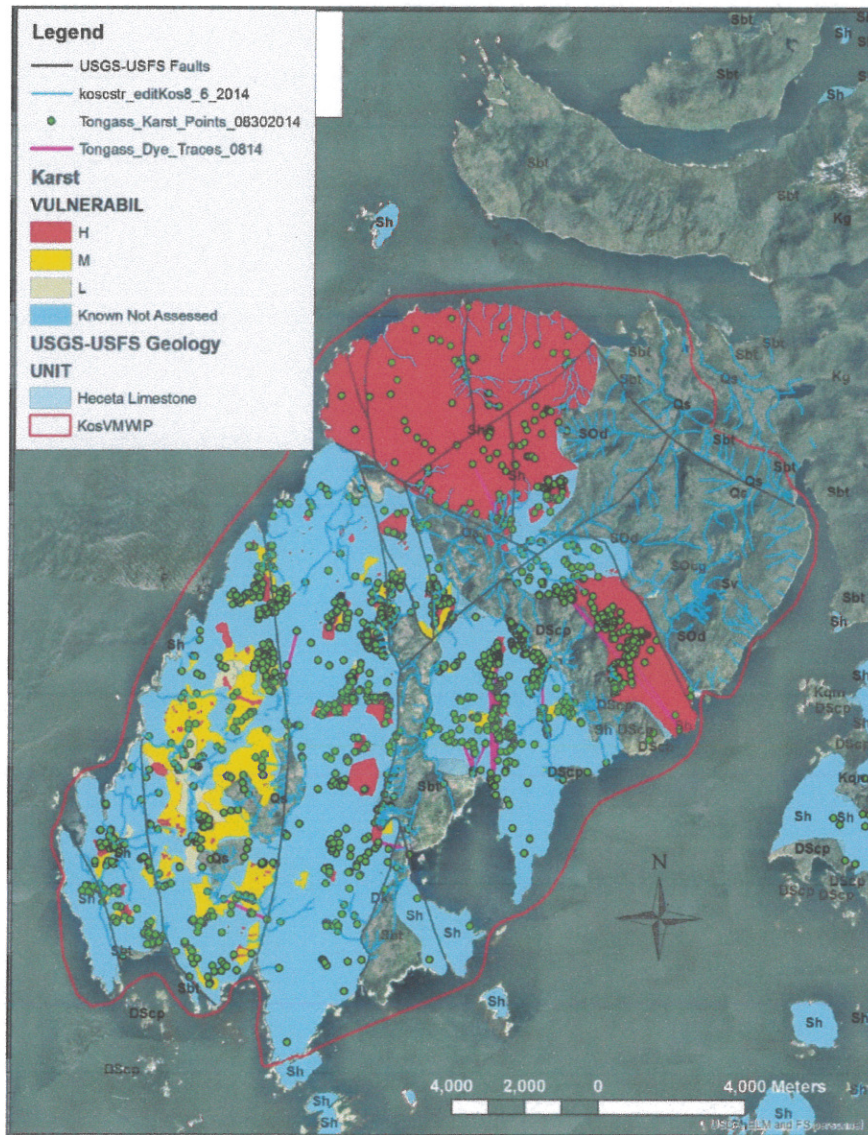


Fig 2. Karst areas, karst vulnerability, dye trace results, and karst features in the project area

In Southeast Alaska the karst landscape can be characterized as an ecological unit found atop carbonate bedrock in which karst features and drainage systems have developed as a result of differential solution by surface and groundwater. These acidic waters are a direct product of abundant precipitation and passage of these waters through the organic-rich forest soil and the adjacent peat lands. Recharge areas may be on carbonate or adjacent non-carbonate substrate.

A few characteristics of this ecological unit include: mature, well developed spruce and hemlock forests along valley floors and lower slopes, increased productivity for plant and animal communities, extremely productive aquatic communities, well-developed subsurface drainage, and the underlying unique cave resources (Baichtal and Swanston, 1996, Wissmar et al., 1997, Bryant et al., 1998).

Within the project area there is approximately 38,659 acres (55.7 mi<sup>2</sup> or 144.3 km<sup>2</sup>) of carbonate bedrock into which karst systems have developed. These systems have developed from sea-level to the highest flanks of Mount Francis. The last glacial advance covered most of the lower elevation karst on the island. Ice is thought to have moved westward and northwest out Sea Otter Sound. It is likely that the ice lobe, which covered most of the project area, may not have exceeded 800-1000 feet in thickness. Glacial outwash deposits immediately east of Cape Pole suggest the position of the terminus of this ice lobe. It is likely that Mount Francis and its flanks escaped all but local glaciation.

The intensity of karst development within the project area reflects the glacial history in both extent of ice cover and timing of deglaciation. It is probable that the thinning ice modified pre-existing karst features and systems less and melted back more rapidly than in other areas of the Archipelago. Karst basins in filled with glacial till, outwash and glacial lacustrine sediments and wetlands have developed on top of these. Numerous karst features now ring the flank of these wetlands where acidic waters flow to discrete recharge areas of the karst systems. Large resurgence streams flow short distances from the spring to the ocean shore across most of the project area. Some large springs feed creeks such as Survey, Charley, and Trout Creeks where they rise from geologic contacts or structural features within the karst systems. Dye traces have illustrated the complexity of these systems and the speed with which waters move through them, exceeding groundwater velocities of 6,500 feet per day.

Under the 2008 Tongass Land Management Plan Amendment, several Geologic Special Interest Areas were created adjacent to and within the project area. These are areas of intense karst development; their unique geomorphologic characteristics, the intensity of karst features found there, and the potential and known significant caves and their associated resources warrant recognition of these areas. 9,342 acres of Geologic Special Area were created in the planning area. In 2014, the National Defense Authorization Act for Fiscal Year 2015 changed some of those Geologic Special Areas to LUDII Geologic Conservation Areas. The land ownership of some of the Geologic Special Areas was transferred to the Sealaska Corporation. Today there are 5,135 acres of LUDII Geologic Conservation Areas and 3,452 acres of Geologic Special Areas. 754 acres of the Mount Francis Geologic Special Area was transferred to Sealaska Corporation. Of the 38,659 acres of karst in the Project Area, 23,569 acres is on lands administered by the Tongass National Forest. 15,090 acres are in private or State of Alaska ownership.

### **Previous Karst Resource Evaluations of the Project Area**

The Forest Service and other parties have made several efforts to inventory and assess the karst and cave resources on Kosciusko Island due to the intensity of karst development. This project began with the Dames and Moore/URS field inventory in October and November of 1999 and in June and July of 2000. LiDAR surveys of the Project Area were flown in the spring of 2000

which contributed high resolution black and white air photography to the project, as well as the derivation of DEMs and contours. Validation of the LiDAR data was conducted as part of this inventory process through an intense air photograph inventory of karst features in the spring of 2000 from both historic and current images. The findings of this inventory were digitized and combined with survey results from the unit reconnaissance. Concurrent with the 1999 field reconnaissance Dames and Moore/URS, the Ozark Underground Lab, and the USFS conducted tracer dye studies to begin definition of the karst watersheds on Kosciusko Island. The findings of these efforts are summarized in the Draft Report, Karst Vulnerability Assessment, Kosciusko Island, Tongass National Forest completed by URS in May of 2001.

To inventory the karst features discovered during field reconnaissance, the USFS working with the Glacier Grotto sponsored cave-mapping expeditions on Kosciusko Island in 1998, 1999, 2001, 2002, 2003, and 2004. Additionally the Tongass Cave Project working under a grant from the Alaska Conservation Foundation conducted field surveys of proposed harvest units in 2000 and 2001. The results of these surveys were provided to the USFS in July 2001. The Tongass Cave Project working with Greenpeace conducted additional surveys on the Island on August 19-25, 2003.

Many smaller inventory and assessment efforts have been conducted on Kosciusko Island from 1998 to the present. Two worth noting was a visit to the Island by the Karst Panel on June 17-18, 2002 and by Kevin Kiernan, visiting geomorphologist and karst management specialist from Tasmania on September 7, 2006.

From August 4, 2006 to August 16, 2006 a four person team revisited 22 of the proposed harvest units analyzed in the Kosciusko Island Timber Sale DEIS from June 2002. The intent of the survey was to verify the karst vulnerability ratings as delineated by URS and incorporate additional data and feature locations provided by the Tongass Cave Project, USFS caving expeditions, and subsequent inventories. During reconnaissance of these units newly discovered features were incorporated into a list with previously discovered and mapped features. All inventory data was brought together to create a revised karst vulnerability rating for each unit. The results from this survey can be found in the Karst Resource Report for the Kosciusko DEIS, Harvest units 543-546, 543-555, 543-558, 543-559, 543-580, 543-581, 543-582, 543-583, 544-594, 544-595, 545-570, 545-584, 546-549, 546-557, 546-561, 546-562, 546-566, 546-568, 546-569, 546-571, 546-665, 546-998 dated August 27, 2006.

In 2007, inventories focused on proposed second growth management units were conducted from July 23 to 27, 2007 and August 8 to 9, 2007. The results of these inventories can be found in the Karst Resource and Cave Resource Report for the 2007 Field Reconnaissance of the Kosciusko Project Area dated September 14<sup>th</sup>, 2007. This report includes harvest units 544-692-07, 544-6100-07, 544-6104-07, 544-6117, and unit 546-542.

August 17th through September 10th, 2010 Johanna Kovarik and three karst resource educated geology field assistants Dan Nolfi, Erin Lynch, and Mark Hagemann inventoried the additional second growth commercial thinning units proposed for harvest for karst and cave resource concerns. The findings of this effort can be found in the Karst Resource and Cave Resource Report for the 2010 Field Reconnaissance of the Kosciusko Project Area dated December 20,

2010. This report includes harvest units 544-688-07, 544-689-07, 544-690-07, 544-691-07, 544-692-07, and 544-693-07.

The USFS, Geologist Johanna Kovarik carried out tracer dye studies between September 7 and October 21, 2010 working to delineate the karst watersheds of Two Car and Car Wash (Community Water) springs and monitor water quality.

In June 26 and July 20, 2014 Ian Putnam, Karina Alfaro, and Sean Maiers conducted additional karst and cave resource assessments of units 54402-519, 54502-505, 54502-501, 54402-502, 54401-508, 54502-513, 54401-504(southern), 54401-504 (northern), 54402-502 (north), 54401-509, 546-557. These are summarized in 2014 Field Reconnaissance of the Kosciusko Project Area dated August 7, 2014 authored by Ian Putnam.

In conjunction with the City of Edna Bay and the Ozark Underground Laboratory from Protem, Missouri additional tracer dye studies were conducted between August 13 and September 2, 2014. The study was funded by local contributions that covered airfare, lodging, meals, and the cost of tracer dyes. Local residents Heather Richter, Carleigh Fairchild, and Tyler Poelstra assisted in sample collection. The Ozark Underground Laboratory (OUL) provided three weeks of professional services by Tom Aley plus laboratory analytical costs *pro bono*. The findings of this study are summarized in the "Delineation of the Recharge Areas for Two Public Water Supply Springs at Edna Bay, Alaska and Recommendations for Protecting their Water Quality" dated April 24, 2015.

### **Karst Vulnerability**

The karst vulnerability of the karst lands on Kosciusko Island have been assessed multiple times and reported on in a myriad of reports. This report focuses on the current planning effort, unit pool, and proposed unit prescriptions by alternative. Much of the past inventory efforts was conducted on lands transferred to Sealaska Corporation in the National Defense Authorization Act for Fiscal Year 2015.

For this exercise it is necessary to roughly define how we applied the karst management standards and guidelines on the ground. Therefore, we will briefly describe our intent and application of the standards and guidelines as directed by the 2008 Tongass Land Management Plan Amendment:

**Low Vulnerability Karst Lands:** These are the carbonate areas most modified by glaciation. They generally have a deep (>40" deep) covering of glacial till and little or no epikarst showing at the surface. Often these were areas of little or no slope (<20%) and we referred to them often as "till planes".

**Moderate Vulnerability Karst Lands:** These are carbonate areas that have a mosaic of shallow organic soils (20-40%, McGilverly Soils) and mineral soils (80-60%, Sarkar[<20" depth] and Ulloa [> 20" depth] Soils) with minor amounts of glacial till. The epikarst is moderate- to well-developed and is visible at the surface. These tend to be at higher elevations, on knobs, ridges, and on the dip-slope of the bedding planes of the limestone when near the surface. These lands posed little or no threat to organic, sediment, and debris introduction into

the karst hydrologic systems beneath. Partial suspension was required on these lands to minimize soil disturbance.

**High Vulnerability Karst Lands:** All collapsed karst features, caves, loosing streams and resurgences. The highest vulnerability features in our opinion (those which could produce and transport the greatest amount of sediment if disturbed) are the till lined sinks and cave entrances which accept a surface stream; whether intermittent or not. Secondly would be till lined sinks. Also considered high vulnerability are karst lands in which the epikarst was well- or extremely well-developed and the soils were predominately (>50%) very shallow organic (<10" deep, McGilvery) and (<50%) mineral (<20" deep, Sarkar). These karst lands, in our opinion, could move organics, sediments, and debris down into the karst hydrologic systems beneath. We considered the entrance area surrounding resurgences to be of high vulnerability as to protect and maintain the environment surrounding the springs and the quality of the waters flowing from them.

Areas with karst development have separate issues and concerns from other landforms because karst landscapes are a three-dimensional with closely integrated surface and subsurface processes. Groundwater flows relatively slowly through porous rock and soil, or through fractures, in non-karst terrain. In karst terrain, groundwater may flow relatively quickly through complex underground systems of fissures and caves. Concerns primarily involve potential changes of groundwater flow in these underground systems. Any management activity that causes sediment or organic debris to build up in the subsurface drainage system decreases its capacity and makes it more likely that surface flow (surface runoff) will occur. Similarly, any management activity that increases the volume of water flowing underground can also make surface flow more likely.

The vulnerability assessment process strives to identify and mitigate the effects of proposed surface management on the karst systems. The karst systems with in the second growth blocks have already been modified by past harvest activity. Primary impacts from past timber harvest have been from sediment transport into karst systems, due to the size of harvest blocks and the rate at which the landscape was harvested. The initial flush of sediment and debris, immediately after harvest with the first storm cycles, is believed to have delivered the majority of the material into the karst systems. Sediment has been transported underground to distant springs, and due to blockage of underground passages, surface flow and erosion increased in some areas. This sediment and debris is delivered into the karst groundwater system both at discrete recharge areas where surface streams flow underground and diffuse recharge through epikarst fractures.

In the Karst Management Standards and Implementation Review, Final Report of the Karst Review Panel (Griffiths, 2002) the panel summarized the lengthy discussions on second growth management. The panel felt that commercial thinning of over-stocked stands would hasten a return to more desirable stand conditions on historically harvested sites. The Panel believes this type of thinning could be safely conducted on low and moderate, and possibly selected high vulnerability karst sites. Commercial thinning has the potential to cause more site disturbance (soils and hydrology). However it was felt that the return of the stand to closer-to-pre harvest tree spacing, canopy closure and canopy interception would be of benefit (to the karst systems). Prussian and Mayn have conducted throughfall studies in order to further understand the linkage between canopy cover and precipitation reaching the forest floor (2006). The results from these

studies, however, are currently inconclusive and early data analysis suggests that the simplified idea that less canopy equals more water flowing through the karst hydrologic system may not be correct. The hydrologic cycle in karst hydrologic systems in temperate rainforest karst ecosystems is complex and not well understood on the Tongass National Forest. In the report by Katherine Prussian, Hydrologist, Thorne Bay Ranger District in 2011, "Throughfall Monitoring - Prince of Wales Island, Alaska" summarizes the throughfall monitoring efforts. Data collected between 2004 and 2008 included 51 storms ranging from 0.4 to 10.6 inches of rainfall. Interception rates, which were derived from the difference between rainfall in the clear cut (CC) sites and throughfall in the second growth (SG) and old growth (OG) sites ranged from 25 to 61%. Interception at the SG sites ranged from 25 to 61%. Interception at the OG sites ranged between 26 and 44%. Even though canopy openings were greater for OG sites than SG sites ( $p = 0.0008$ ), interception was found to be not significantly different ( $p = 0.75$ ). Results of this study, contrast to the results of other studies comparing OG and SG forests, and identify three issues that need to be resolved in order to affectively assess effects of forest management: 1) Size, density, productivity and canopy characteristics of old-growth and second-growth forests, vary considerably. Variation in these forest attributes may exceed differences associated with age of forest, 2) Present use of open sky measurements and/or throughfall collection devices may not adequately describe pattern of over story interception, 3) relevant measures of forest over story need to be made in order to compare between forest types.

### **Karst Resources within the Project Area.**

#### **Existing Condition**

The 38,659 acres of the Project area is underlain by limestone. We assume that karst has developed on all those acres. Approximately 53.6% or 20,718 acres of karst in the Project Area have been harvested historically. The USFS manages some 23,569 acres of karst in the Project Area of which 62.1% or 14,634 acres have been harvested historically. Where karst systems have developed adjacent and beneath harvested areas, it is possible that sedimentation and slash from prior harvest washed into karst features, altering the ecology of the karst system through effecting the water chemistry and flow paths (Aley et al. 1993). It is also possible that in areas that have already been harvested, thickly regenerated forests are causing greatly increased interception rates resulting in less water moving through the karst systems (Prussian 2008). Without the natural flow rates through the system, slash and debris will remain instead of being washed out. In addition, decreased water flow downstream from these karst areas results in a reduction of fish habitat where karst streams contribute to fish streams (Bryant et. al 1998). High and moderate vulnerability karst is most susceptible to these effects, as outlined in the prior section. In the Kosciusko Project Area there is evidence that extensive timber management has changed the infiltration rate of soils and bedrock in the karst landscape at the head of Survey Creek (now Sealaska Corporation land). Water that used to go subsurface now flows on the surface for part of the year. This overland flow eroded soils and exposed bedrock and dense till in a braided stream channel up to 10 meters wide.

#### **Desired Condition**

Maintain to the extent practical the natural karst processes and the productivity of the karst landscape while providing for other land uses, where appropriate. Strive to maintain the productivity of the soils of the karst landscape and the quantity and quality of the waters issuing

from the karst hydrologic systems. Protect the many resource values within underlying significant cave systems as per the requirements of the Federal Cave Resources Protection Act of 1988.

## Environmental Consequences for Alternatives

**Table 1. Acres of Karst Treated by Alternative and Harvest Type**

Acres of Karst Treated by Alternative and Harvest Type																			
HARVEST_CO	CC				CCYG				UAYG				UAOG		Two-Aged				
Vulnerability	L	M	H	KNA	L	M	H	KNA	L	M	H	KNA	M	H	L	M	H	KNA	Total
Alternative 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Alternative 2	0.00	25.90	0.00	0.76	53.57	775.92	27.75	3.33	3.57	60.98	8.55	0.00	36.56	0.18	0.00	0.00	0.00	0.00	997.07
Alternative 3	0.00	25.90	0.00	0.76	0.00	391.97	4.05	0.01	4.76	176.83	22.48	3.46	36.56	0.18	60.69	755.47	40.08	0.12	1523.32
Alternative 4	0.00	25.90	0.00	0.76	0.00	0.00	0.00	0.00	65.45	942.06	65.20	9.31	36.56	0.18	0.00	388.37	10.97	0.00	1544.76

**Table 2. Acres of Karst Treated by Alternative and Pre-commercial Thinning Harvest Type**

Acres of Karst Treated by Alternative and Precommercial Thinning Harvest Type										
HARVEST_CO	PCT				Total	PCTR				Total
Vulnerability	L	M	H	KNA	Acres	L	M	H	KNA	Acres
Alternative 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Alternative 2	0.10	1.62	993.86	598.38	1593.96	0.00	2.71	20.24	142.69	165.64
Alternative 3	0.10	1.62	993.86	598.38	1593.96	0.00	2.71	20.24	142.69	165.64
Alternative 4	0.10	1.62	993.86	598.38	1593.96	0.00	2.71	20.24	142.69	165.64

### Alternative 1: No Action

**Indirect Effects and Cumulative Effects:** The no action alternative is just as stated. If this alternative is chosen, no harvest or road building would occur within the project area.

### Alternative 2

**Direct and Indirect Effects:** This alternative would harvest approximately 997.1 acres of karst and pre-commercially thin 1759.6 acres of karst. This Alternative would clear cut 27 acres of mature forest and selectively harvest an additional 37 acres. The high vulnerability acres indicated in each harvest category in Table 1 will be excluded from harvest. A large portion of the acreage to be pre-commercially thinned is in Geologic Special Interest Areas or LUDII Geologic Conservation Areas and is mapped as high vulnerability. Individual features will be appropriately buffered.

**Cumulative Effects:** This Alternative would harvest approximately 64 acres of mature forest and 933.1 acres of second growth by a variety of methods. This would increase the harvested karst by 0.27%, most harvest occurring on already harvested karst lands. No commercial harvest will occur on high vulnerability lands. Though not statistically proven, it is believed that some of the harvest treatments will returning the stand to closer-to-pre-harvest tree spacing, thus hastening the hydrologic recovery of the site. Reducing the canopy cover could restore the 'health' of second growth forests on karst lands by increasing the volume of throughfall, flushing sedimentation out of diffuse and discrete karst openings, and reconnecting surface to subsurface flow pathways. The management of older second growth stands can also hasten the return to more natural stand characteristics and conditions. It is believed that per-commercial thinning in the Geologic Special Interest Areas or LUDII Geologic Conservation

Areas is appropriate so that in the future commercial thinning of those stands would hasten the return to more natural stand characteristics and conditions. No negative cumulative effects are anticipated by this alternative.

### **Alternative 3**

**Direct and Indirect Effects:** This alternative would harvest approximately 1544.8 acres of karst and pre-commercially thin 1759.6 acres of karst. This Alternative would clear cut 27 acres of mature forest and selectively harvest an additional 37 acres. The high vulnerability acres indicated in each harvest category in Table 1 will be excluded from harvest. A large portion of the acreage to be pre-commercially thinned is in Geologic Special Interest Areas or LUDII Geologic Conservation Areas and is mapped as high vulnerability. Individual features will be appropriately buffered.

**Cumulative Effects:** This Alternative would harvest approximately 64 acres of mature forest and 1480.8 acres of second growth by a variety of methods. This would increase the harvested karst by 0.27%, most harvest occurring on already harvested karst lands. No commercial harvest will occur on high vulnerability lands. Though not statistically proven, it is believed that some of the harvest treatments will returning the stand to closer-to-pre-harvest tree spacing, thus hastening the hydrologic recovery of the site. Reducing the canopy cover could restore the 'health' of second growth forests on karst lands by increasing the volume of throughfall, flushing sedimentation out of diffuse and discrete karst openings, and reconnecting surface to subsurface flow pathways. The management of older second growth stands can also hasten the return to more natural stand characteristics and conditions. It is believed that per-commercial thinning in the Geologic Special Interest Areas or LUDII Geologic Conservation Areas is appropriate so that in the future commercial thinning of those stands would hasten the return to more natural stand characteristics and conditions. No negative cumulative effects are anticipated by this alternative.

### **Alternative 4**

**Direct and Indirect Effects:** This alternative would harvest approximately 1523.3 acres of karst and pre-commercially thin 1759.6 acres of karst. This Alternative would clear cut 27 acres of mature forest and selectively harvest an additional 37 acres. The high vulnerability acres indicated in each harvest category in Table 1 will be excluded from harvest. A large portion of the acreage to be pre-commercially thinned is in Geologic Special Interest Areas or LUDII Geologic Conservation Areas and is mapped as high vulnerability. Individual features will be appropriately buffered.

**Cumulative Effects:** This Alternative would harvest approximately 64 acres of mature forest and 1459.3 acres of second growth by a variety of methods. This would increase the harvested karst by 0.27%, most harvest occurring on already harvested karst lands. No commercial harvest will occur on high vulnerability lands. Though not statistically proven, it is believed that some of the harvest treatments will returning the stand to closer-to-pre-harvest tree spacing, thus hastening the hydrologic recovery of the site. Reducing the canopy cover could restore the 'health' of second growth forests on karst lands by increasing the volume of throughfall, flushing sedimentation out of diffuse and discrete karst openings, and reconnecting surface to subsurface flow pathways. The management of older second growth stands can also hasten the return to more natural stand characteristics and conditions. It is believed that per-commercial thinning in the Geologic Special Interest Areas or LUDII Geologic Conservation

Areas is appropriate so that in the future commercial thinning of those stands would hasten the return to more natural stand characteristics and conditions. No negative cumulative effects are anticipated by this alternative.

### **Roads on Karst**

For all alternatives specific requirements concerning road building on moderate vulnerability (Appendix H, section III.A.4.b.ii ) and high vulnerability karst (Appendix H, section III.A.4.b.ii) are located in the Forest Plan. Road building on high vulnerability karst would be avoided under all alternatives. Any specific mitigation will be addressed on the Road Cards.

### **Mitigation for Alternatives 2,3, and 4**

This proposal is also designed to enhance karst hydrologic function and maintain, to the extent practicable, the natural karst processes and the productivity of the karst landscape. Within the project area there are approximately 38,659 acres of carbonate bedrock in which karst systems have developed; 23,569 on USFS lands.. In karst terrain, groundwater may flow relatively quickly through complex underground systems of fissures and caves. Concerns primarily involve potential changes of groundwater flow in these underground systems. Any management activity that causes sediment or organic debris to build up in the subsurface drainage system may degrade natural karst processes and the productivity of the karst landscape. The majority of past timber management and road construction activities occurred prior to there being any measures for karst resource protection. Past activities caused sediment to be delivered into karst systems and some blockages have occurred. These blockages have increased surface flow and erosion in some areas. Opportunities exist to improve the karst systems where ditches, culverts, slash, and beaver dams/structures are impeding natural water flows or creating unnatural water flows to karst features.

Common to all action alternatives

- Where karst systems have been impacted, blockages may be removed and diverted water flow from culverts and ditch features would be remedied. ...

### **Monitoring**

It is suggested that both the through fall and spring discharge be monitored within and adjacent to the units where commercial thinning of second growth occurs. It is proposed that during the winter and spring before harvest begins that tracer dye studies be conducted to determine where the karst drainages within the unit contribute waters to. Hopefully, these systems contribute waters to a single stream segment or spring. Data loggers with pH, conductivity, temperature, flow and turbidity probes should be installed at these sites. Within the proposed treatment areas, a number of rain gauges should be installed to gather background data on throughfall in the existing stands. Several rain gauges should also be installed in appropriate areas to gather total precipitation data for these sites. This would allow precipitation, throughfall, and stream and spring characteristics to be monitored before harvest occurs. These monitoring stations should be maintained as long as possible before harvest, during harvest, and post-harvest. This way we can hopefully quantify the effects of the harvest on the associated karst groundwater systems.

## References

- Aley, T., C. Aley, W. Elliot, and P. Huntoon. 1993. Karst and cave resource significance assessment, Ketchikan Area, Tongass National Forest, Alaska, Draft Report, prepared for the Ketchikan Area of the Tongass National Forest. 76 pp. + appendix.
- Baichtal, J.F.; and D.N. Swanston. 1996. Karst Landscapes and Associated Resources: A Resource Assessment. General Technical Report, PNW-GTR-383. Portland, Oregon: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 13p.
- Bryant, M.D.; D.N. Swanston; R.C. Wissmar; and B. E. Wright. 1998 Coho Salmon Populations in the Karst Landscape of Northern Prince of Wales Island, Southeast Alaska. *Transactions of the American Fisheries Society* 127:425-433, 1998
- Carlson, Risa J. and James F. Baichtal, 2015 A Predictive Model for Locating Early Holocene Archaeological Sites Based on Raised Shell-Bearing Strata in Southeast Alaska, USA *Geoarchaeology: An International Journal* 30 (2015) 120–13
- Eberlein, G.D., and Churkin, Csejtey, Jr., 1970, Paleozoic stratigraphy in the northwest coastal area of Prince of Wales Island, southeastern Alaska: U.S. Geological Survey Bulletin 1284, 67 p., 2 sheets, scale 1:125,000
- Griffiths, P.; Aley, T.; Worthington, S.; Jones, W. 2002. Karst Management Standards and Implementation Review, Final Report of the Karst Review Panel, Prepared for USDA Forest Service, Tongass National Forest, Submitted to MWH (Montgomery Watson Harza) under the terms of USDA Contract 53-0116-2-55901, 27 pp. and appendices.
- Maas, K.M., Bittenbender, P.E., and Still, J.C., 1995, Mineral investigations in the Ketchikan mining district, southeastern Alaska: U.S. Bureau of Mines Open-File Report 11-95, 606 p
- Prussian, K. and Mayn, C. 2006 Preliminary Throughfall Results from 23 storm events, personal communication, unpublished preliminary results.
- Prussian, K 2011 Throughfall Monitoring - Prince of Wales Island, Alaska. Unpublished USFS Internal Document.
- Wissmar, R.C. D.N. Swanston, M. D. Bryant; and K McGee. 1997 Factors Influencing Stream Chemistry in Catchments on Prince of Wales Island, Alaska. *Freshwater Biology* (1997) 38, 301-314.

If you have any questions or concerns related to the above report, please feel free to contact me at the information provided below.

Sincerely,



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